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Risk analysis of landslide disaster in Ponorogo, East Java, Indonesia

S Koesuma[1,3*], **A P Saido**[2], **Y Fukuda**[3]

[1]Department of Physics. Universitas Sebelas Maret. Surakarta Indonesia
[2]Department of Civil Engineering. Universitas Sebelas Maret. Surakarta Indonesia.
[3]Graduate School of Sciences, Kyoto University, Kyoto, Japan
[*]E-mail : sorja@uns.ac.id

Abstract Ponorogo is one of regency in South-West of East Java Province, Indonesia, where located in subduction zone between Eurasia and Australia plate tectonics. It has a lot of mountain area which is disaster-prone area for landslide. We have collected landslide data in 305 villages in Ponorogo and make it to be Hazards Index. Then we also calculate Vulnerability Index, Economic Loss index, Environmental Damage Index and Capacity Index. The risk analysis map is composed of three components H (Hazards), V (Vulnerability, Economic Loss index, Environmental Damage Index) and C (Capacity Index). The method is based on regulations of National Disaster Management Authority (BNPB) number 02/2012 and number 03/2012. It has three classes of risk index, i.e. Low, Medium and High. Ponorogo city has a medium landslide risk index.

1. Introduction

Ponorogo is a regency in East Java Province, which is located between 111 ° 17 ' – 111° 52' E and 7°49'N – 8°20'S with an area of 1371.78 km^2. Ponorogo located in southern part of Java island which is a subduction zones between the Australian plate and the Eurasian plate. The impact of subduction process is the uplifting and folding of geological strata forming such varied geomorphology sloping plains, hills and mountains. Such geological conditions makes Ponorogo have the potential threat of landslide disaster.

There is a study concerning landslide in Ponorogo, Basofi et. al [1] has a classification of landslide by using Natural Breaks and Head/tail Breaks methods, and then compare the both of result to get the landslide hazard map. The hazard map result is slightly different with our results, especially in the southern part of Ponorogo regency.

Some researchers has clasified the landslide into several types. Varnes [2] has clasified the landslide into 29 types which are divided in five major components, i.e. (i) relating to movement, (ii) relating to material, (iii) relating to geologic, geopmorphic, geographic, or climate setting, (iv) relating to size or geometry and (v) relating to age or state of activity. Hungr [3] accomplished the landslide types into 32 types. It is not added some new type of landslide but because of its ambiguities in different point of view, especially where a landslide type is graded from other, without a clear-cut boundary. The USGS special report [4] shows a good ilustration of some landslide types and its caused. This paper will discuss the risk analysis of landslide in Ponorogo regency based on hazard, vulnerability and capacity parameters. Landslide hazard map in Ponorogo regency is shown in Figure 1.

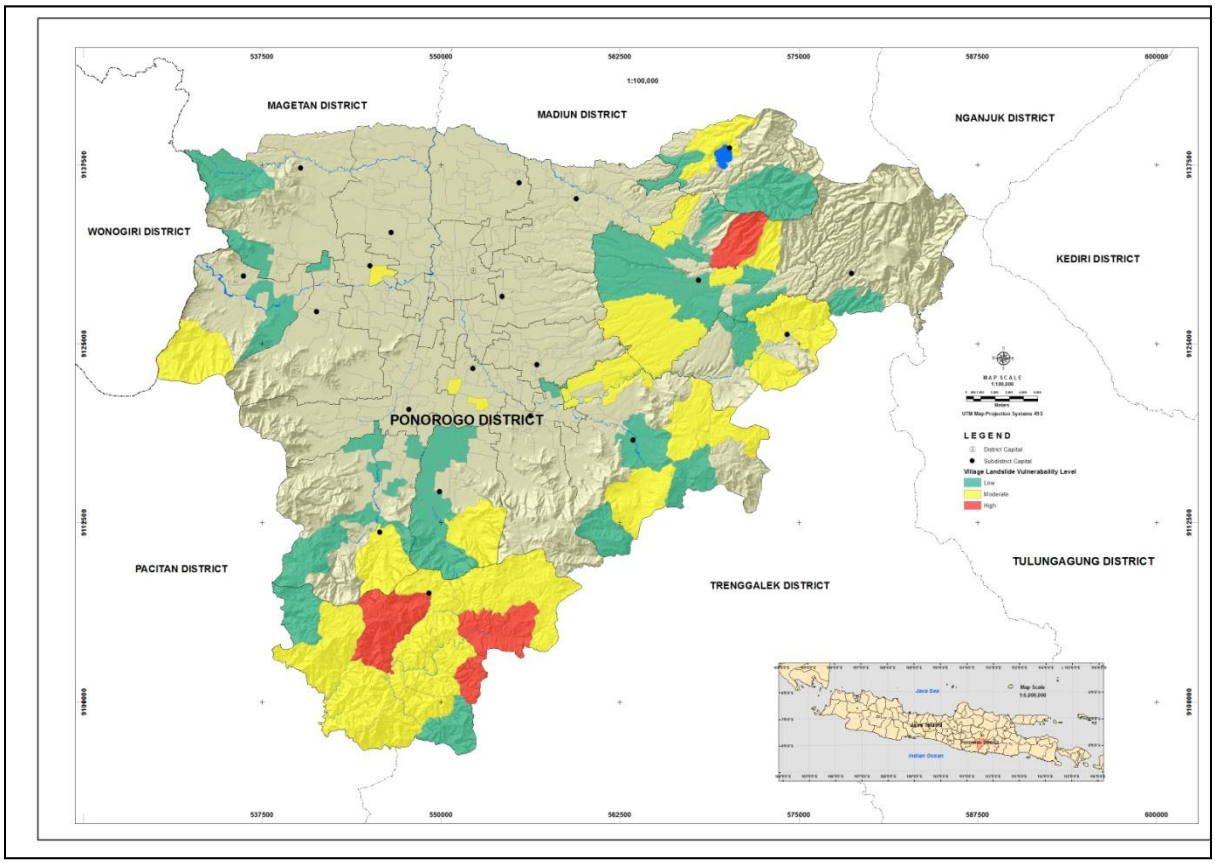

Figure 1. Landslide Hazard Map. Inserted map in right bottom is Java island.

2. Method

The risk analysis map is composed of three components H (Hazards), V (Vulnerability, Economic Loss index, Environmental Damage Index) and C (Capacity Index). We used the method proposed in the regulations of National Disaster Management Authority (BNPB) number 02/2012 [5] and number 03/2012 [6], in formula form:

$$R = H\ x\ \frac{V}{C} \quad (1)$$

The H hazards map shown in figure 1 is based on event of landslide which happened in an area. The map is composed in village-based data, so we collected the landslide data in village in the last 3 years. Most of landslide event are in southern part and western part of Ponorogo. These area are hills, mountains and foot of mountain. The V component is composed by three parameters which are vulnerability of residents againts landslide disaster (figure 2.a), economic loss caused by disaster and environmental damage caused by landslide (figure 2.b.). Those three parameters are summed and then mapped together with other parameters.

Stakeholder Capacity Index in disaster management is a hint of a capability of being owned by the region in the implementation of disaster management or a regional capability and communities to take action to reduce the threat and potential catastrophic losses as a result of a structured, planned and integrated. We make a questionnaire to calculate Stakeholder Capacity Index based on BNPB regulation number 3/2012 [6], and we found that the capacity index is 55 point (Medium index), and then mapped as shown in figure 2.c.

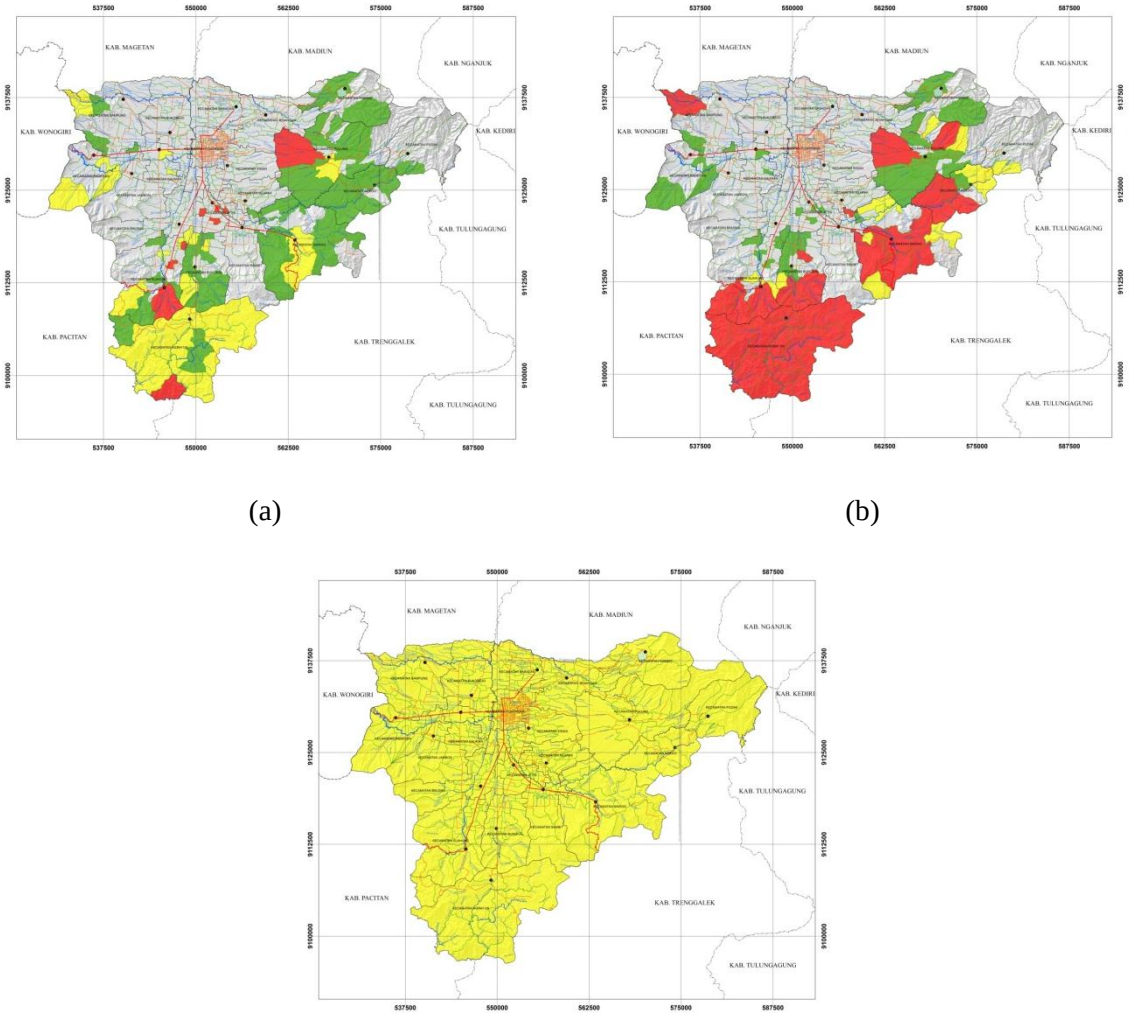

Figure 2. Map of (a) Vulnerability, (b) Economic Loss – Enviromental Damage, (c) Capacity

3. Discussions

Kohler et.al [7] stated that Risk analysis consists of hazard analysis and vulnerability analysis, together with analysis of protec tive capabilities. Some authors treat the analysis of the protective capabilities of the local population (coping strategies) as part of vulnerability analysis, others as a third component of risk analysis, others see it as an additional chapter, and as such a component of risk assessment and not risk analysis. Otherwise, Bell and Glade [8] did a quantitative risk analysis for landslide, and divided many parameters which is affect the risk analysis. For instance in consequence analysis, there are element risk, vulnerability, probability of spatial impact, probability of temporal impact and probability of seasonal impact. Other researcher Guzzeti et.al [9] propose a new tool to inventory landslide map, which is consist three aspects (i) analysis of surface morphology, chiefly exploiting very-high resolution digital elevation models (DEMs), (ii) interpretation and analysis of satellite images, including panchromatic, multispectral and synthetic aperture radar (SAR) images, and (iii) the use of new tools to facilitate field mapping.

The landslide risk map that have been made is based on village area, actually the data in each village shows some variations. There are ome villages with low, medium and high value respectively, but after an average of all value, the risk index is become medium value. There are 79 village which have landslide hazard, we resume the component in the following table. Based on the calculation on risk

analysis in formula (1), we found that Ponorogo city have a medium landslide index with average point 9.5 [5].

Table 1. Village with landslide disaster risk

No	Sub	Village	Hazards	Vulnerability	Economic	Environment
1	Ngrayun	Desa Baosan	10	0,8	1,8	0,3
2		Desa Wonodadi	5	0,8	1,8	0,3
3		Desa Sendang	10	0,8	1,8	0,3
4		Desa Mrayan	10	0,8	1,8	0,3
5		Desa Binade	5	0,4	1,8	0,3
6		Desa Baosan Lor	15	0,8	1,8	0,3
7		Desa Ngrayun	10	0,8	1,8	0,3
8		Desa Temon	10	0,4	1,8	0,3
9		Desa Selur	15	0,8	1,8	0,3
10		Desa Cepoko	10	0,8	1,8	0,3
11		Desa Gedangan	10	1,2	1,8	0,3
12	Slahung	Desa Tugurejo	5	0,8	1,8	0,3
13		Desa Senepo	5	0,4	1,8	0,3
14		Desa Slahung	10	1,2	1,8	0,3
15		Desa Broto	5	0,4	1,8	0,2
16		Desa Plancungan	5	0,8	1,8	0,1
17		Desa Galak	5	1,2	1,8	0,1
18		Desa Crabak	5	1,2	1,8	0,1
19		Desa Mojopitu	5	0,8	1,8	0,1
20		Desa Gundik	5	0,8	1,8	0,1
21		Desa Janti	5	0,4	1,8	0,1
22	Bungkal	Desa Pelem	5	0,4	1,8	0,3
23		Desa Koripan	5	0,8	1,8	0,3
24		Desa Bekare	5	0,8	1,8	0,2
25		Desa Nambak	5	0,4	1,8	0,1
26		Desa Kalisat	5	0,4	1,8	0,1
27		Desa Munggu	10	0,4	1,8	0,3
28		Desa Ketonggo	5	0,4	1,8	0,1
29		Desa Kunti	5	0,4	1,8	0,1
30		Desa Bancar	10	0,4	1,8	0,1
31		Desa Padas	5	0,4	1,8	0,3
32		Desa Bungu	5	0,8	1,8	0,1
33		Desa Bedi Wetan	5	0,4	1,8	0,1
34		Desa Bedi Kulon	5	0,8	1,8	0,1
35	Sambit	Desa Kemuning	5	0,4	1,8	0,3
36	Sawoo	Desa Tumpuk	5	0,4	1,8	0,2
37		Desa Pangkal	5	0,8	1,8	0,3
38		Desa Tumpak	5	0,4	1,8	0,3
39		Desa Sriti	10	0,4	1,8	0,2
40		Desa Temon	10	0,4	1,8	0,3
41		Desa Sawoo	5	0,8	1,8	0,3
42		Desa Prayungan	10	0,4	1,8	0,3
43		Desa Tugurejo	10	0,4	1,8	0,2
44		Desa Grogol	10	0,4	1,8	0,3
45		Desa Ketro	10	0,4	1,8	0,1
46		Desa Bondrang	10	0,4	1,8	0,2
47		Desa Ngindeng	10	0,4	1,8	0,2
48	Sokoo	Desa Ngadirojo	10	0,4	1,8	0,3
49		Desa Klepu	10	0,4	1,8	0,3
50		Desa Suru	5	0,4	1,8	0,3
51		Desa Sooko	10	0,4	1,8	0,1
52		Desa Jurug	10	0,4	1,8	0,2
53	Pudak	Desa Banjarjo	5	0,4	1,8	0,2
54	Pulung	Desa	10	0,4	1,8	0,1
55		Desa Bedrug	5	0,4	1,8	0,1
56		Desa Singgahan	5	0,4	1,8	0,1

57		Desa Patik	10	0,4	1,8	0,1
58		Desa Pulung	5	0,8	1,8	0,1
59		Desa Pulung	5	0,4	1,8	0,1
60		Desa Sidoharjo	5	1,2	1,8	0,3
61		Desa Plunturan	5	0,4	1,8	0,1
62		Desa Pomahan	10	0,4	1,8	0,1
63		Desa Serag	5	0,4	1,8	0,2
64		Desa Munggung	15	0,4	1,8	0,3
65		Desa Bekiring	10	0,4	1,8	0,2
66	Jetis	Desa	10	1,2	1,8	0,1
67		Desa Jetis	10	1,2	1,8	0,1
68	Kauman	Desa Ploso Jenar	10	0,8	1,8	0,1
69	Jambon	Desa Srandil	5	0,4	1,8	0,1
70	Badegan	Desa Dayakan	10	0,8	1,8	0,1
71		Desa Karang Joho	5	0,8	1,8	0,1
72		Desa Tanjung	5	0,8	1,8	0,1
73	Sampung	Desa Gelang	5	0,4	1,8	0,1
74		Desa Pohijo	5	0,8	1,8	0,3
75		Desa Jenangan	5	0,4	1,8	0,3
76	Ngebel	Desa Ngrogung	5	0,4	1,8	0,1
77		Desa Sahang	10	0,4	1,8	0,1
78		Desa Talun	5	0,4	1,8	0,1
79		Desa Ngebel	10	0,4	1,8	0,1
Total			**586**	**46.8**	**142.2**	**15.4**
Average			**7.4**	**0.59**	**1.8**	**0.19**
Risk Index				**7.4 x (0.59 +1.8+0.19)/2**		**9.5**
				Medium		

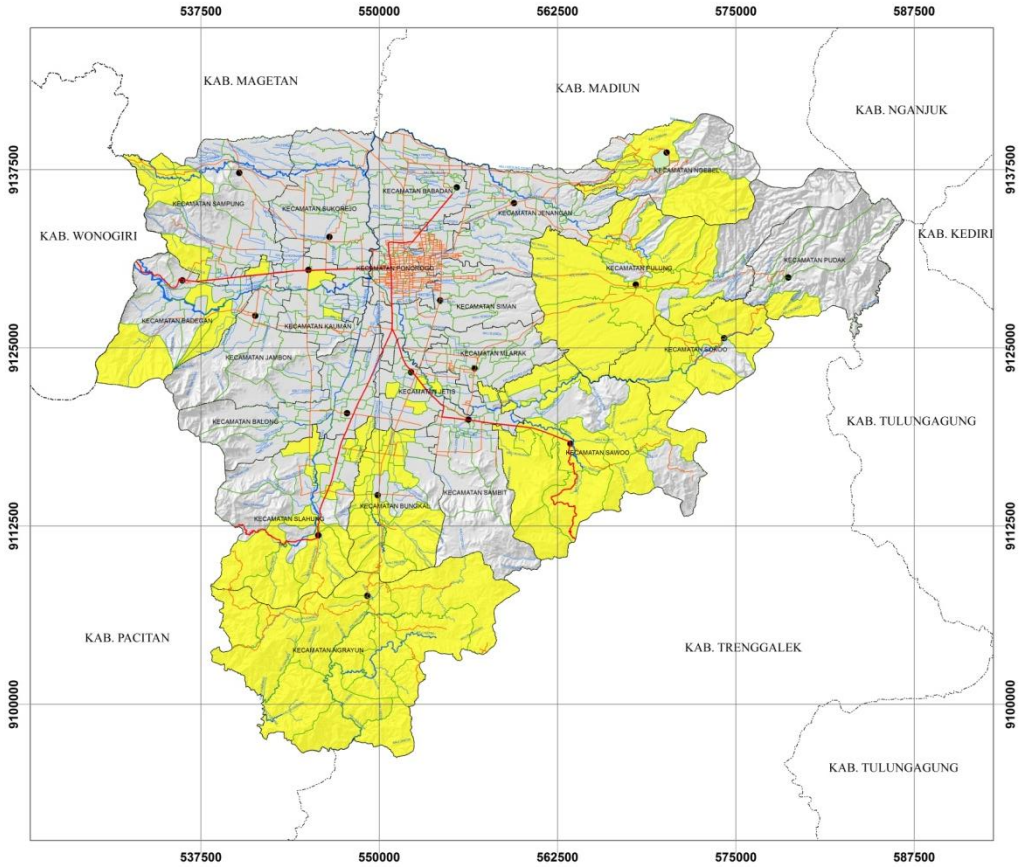

Figure 3. Landslide risk map

4. Conclusions

Ponorogo city have a medium risk of landslide with average index point 9.5. Generally the location of landslide hazards are in southern part of city, where a lot of mountains and part of Sewu Mountains. Based on this result, there are two recommendations, first, Contigency Plan should be prepared by stakeholder, business sector and communities. Secondly, Disaster Mitigation Plan on village level should be made in order to more focus on landslide disaster prevention.

5. References

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